Did North Atlantic cooling and freshening from 3.65–3.5 Ma precondition Northern Hemisphere ice sheet growth?

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Abstract

The North Atlantic Current (NAC) as part of the Atlantic Meridional Overturning Circulation (AMOC) is the major supplier of heat into the northern North Atlantic. Pliocene changes of AMOC strength were speculated to either have amplified or diminished the Northern Hemisphere Glaciation (NHG) 2.7 million years ago (Ma). However, from the North Atlantic, little evidence is known about AMOC changes at around 3.6 Ma. At this time the intensification of NHG started and culminated in the first major glacial M2 event at 3.3 Ma. To elaborate the climatic effects of variations in the NAC during this early stage of NHG, we here present millennial-scale resolved records from Deep Sea Drilling (DSDP) Site 610A in the northern North Atlantic. Our data of planktic foraminiferal Mg/Ca-based sea surface temperatures ($SST_{Mg/Ca}$) and ice volume corrected salinity approximations ($\delta^{18}O_{IVC\text{-}seawater}$) span the critical time period 4–3.3 Ma. From 3.65 to 3.5 Ma, we observe a distinct ~3.5 °C cooling and ~0.7‰ freshening of the sea surface, which we interpret to reflect a weakened NAC. At the same time Arctic sea ice grew and benthic $\delta^{13}C$ in the South Atlantic suggest a weakened AMOC. We conclude that the weakened NAC in response to a sluggish AMOC fostered sea ice formation in the Arctic Ocean and high-latitude North Atlantic, which might have preconditioned the climate for subsequent continental glaciations.